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Chemistry 1110 Spring 2024 Test 2

Wednesday, February 28, 2024 Time: 1 hour 50 minutes

Name: ANSWERS Student #: _____

*This test consists of **nine** pages of questions, a page of useful constants and conversions, a page containing functional group information, and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **56** marks (and three bonus marks) available. Good luck!*

1) **[2 marks]** At 51.55°C and 1 bar pressure a compound of formula OF_n has a density of 2.0000 g/L. What is the value of n?

$$MM = \frac{(2)(0.083144626 18)(324.7)}{1} = 53.99\ldots \frac{g}{mol}$$

$$15.999 + n(18.998) = 53.99\ldots$$

$$\Rightarrow \boxed{n = 2}$$

2) **[2 marks]** My watch is water-resistant to a pressure of 5 bars. Assuming water has a density of 0.9984 g/cm^3, to how many metres of water may I safely take my watch?

$$5\,bar \times \frac{100{,}000\,Pa}{1\,bar} = 500{,}000\,Pa$$

$$0.9984 \frac{g}{cm^3} \times \frac{1\,kg}{1000\,g} \times \left(\frac{100\,cm}{1\,m}\right)^3 = 998.4 \frac{kg}{m^3}$$

$$500{,}000 = 998.4 \times 9.80665 \times h$$

$$\Rightarrow \boxed{h = 51.07\,m}$$

3) **[4 marks total]** A gas mixture consists of three gases (gas A, gas B, and gas C). The mole fraction of gas A is 0.2. There are three moles of gas B, and the partial pressure of gas C is 10 atm. If the total pressure of the mixture is 20 atm:

a) **[2 marks]** Calculate the mole fractions of gases B and C.

$X_C = \frac{10}{20} = 0.5$

$X_B = 1 - 0.5 - 0.2 = 0.3$

b) **[2 marks]** Calculate the partial pressures of gases A and B. Give your answers in atm.

$P_A = (0.2)(20) = 4 \text{ atm}$

$P_B = (0.3)(20) = 6 \text{ atm}$

c) **[3 marks - BONUS]** Calculate the moles of gases A and C.

A = moles of gas A

C = moles of gas C

$0.2 = \frac{A}{A+C+3} \Rightarrow 0.2A + 0.2C + 0.6 = A$

$\Rightarrow 0.8A - 0.2C = 0.6 \quad (1)$

$0.5 = \frac{C}{A+C+3} \Rightarrow 0.5A + 0.5C + 1.5 = C$

$\Rightarrow -0.5A + 0.5C = 1.5 \quad (2)$

$(1) \times 5 + (2) \times 2$

$4A - C = 3$

$-A + C = 3$

$3A = 6$

$A = 2$

$0.2 = \frac{2}{5+C}$

$1 = \frac{10}{5+C} \Rightarrow C = 5$

2 moles of gas A

5 " " " C

4) **[4 marks]** The following apparatus was assembled:

Bulb 1:
Volume: 4 litres
Gas: C_2H_2
Pressure: 2280 torr

Bulb 2:
Volume: 6 litres
Gas: H_2
Pressure: 1520 torr

The two bulbs were separated by a valve. When the valve was opened, the following reaction occurred:

$$C_2H_2(g) + 2H_2(g) \longrightarrow C_2H_6(g)$$

Both bulbs were maintained at a temperature of 945.51°C before, during, and after reaction. Calculate the partial pressures of all species ***after reaction***.

$n_{C_2H_2} = \frac{9120}{RT}$; $n_{H_2} = \frac{9120}{RT}$

LR check:

$\frac{9120}{RT}$ moles $C_2H_2 \times \frac{1\ rxn}{1\ C_2H_2} = \frac{9120}{RT}$ moles rxn

$\frac{9120}{RT}$ moles H_2 (LR) $\times \frac{1\ rxn}{2\ H_2} = \frac{4560}{RT}$ moles rxn

C_2H_2 L.O.: $\frac{9120}{RT}$ moles $C_2H_2 - \frac{9120}{RT}$ moles $H_2 \times \frac{1\ C_2H_2}{2\ H_2} = \frac{4560}{RT}$

C_2H_6 made: $\frac{9120}{RT}$ moles $H_2 \times \frac{1\ C_2H_6}{2\ H_2} = \frac{4560}{RT}$ moles C_2H_6

$$P_{C_2H_2} = P_{C_2H_6} = \frac{\frac{4560}{RT} \times RT}{10} = 456 \text{ torr}$$

$P_{H_2} = 0$

5) **[3 marks]** A gas of formula SCl_n effuses about 30 percent faster than a gas of formula SCl_{n+2}. What is the value of n?

$$M_n \times (1.3r)^2 = M_{n+2}(r)^2$$

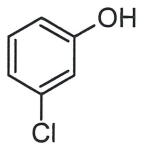
$$\downarrow$$

$$(S + n\cdot Cl)(1.69) = S + (n+2)Cl$$

$$1.69S + 1.69\cdot n\cdot Cl = S + n\cdot Cl + 2\cdot Cl$$

$$0.69S + n(0.69Cl) - 2\cdot Cl = 0$$

$$n = \frac{2\cdot Cl - 0.69\cdot S}{0.69\,Cl} = \boxed{2}$$

6) **[4 marks]** For the molecule 

a) The number of bonding pairs of electrons is: 16

b) The number of non-bonding (lone) pairs of electrons is: 5

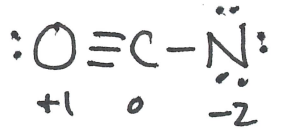
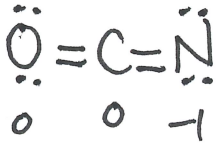
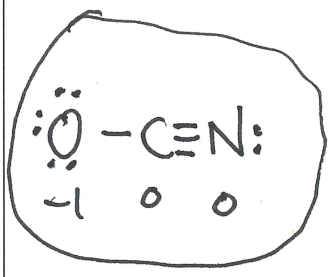
c) The number of sigma bonds is: 13

d) The number of pi bonds is: 3

7) **[5 marks]** Complete the following table for the OCN^{-1} ion (C the centre atom):

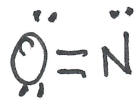
- Include all non-zero formal charges.
- Circle the "best" resonance form.
- Draw only non-equivalent resonance forms.

I'll mark only what you write in the table; you can use the rest of the page for rough work (if you wish).

Resonance Form 1	Resonance Form 2	Resonance Form 3
		

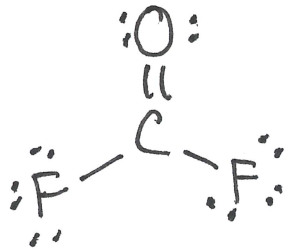
8) **[4 marks]** The NO molecule tends to dimerize (attach to another NO molecule) while the NO^+ ion does not. Give a possible explanation for this using Lewis structures.

NO has 11 electrons available for bonding. 1 will be unpaired.



NO^+ has no unpaired electrons available to form bonding pairs of electrons.

9) **[2 marks]** The OCF_2 molecule (C the centre atom, other atoms attached only to it) has only one possible Lewis resonance form. Why?

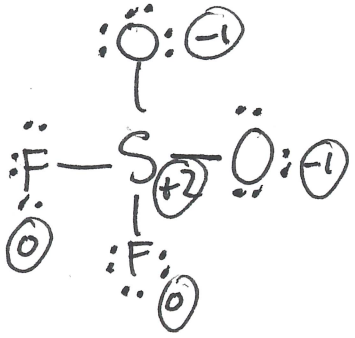
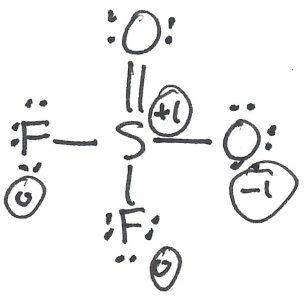
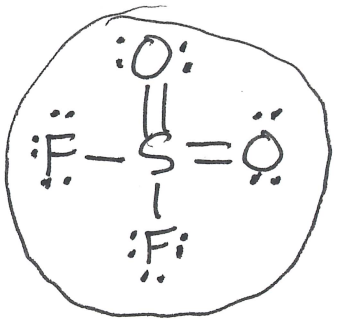


Any other resonance form would require a double bond between C and F, which cannot happen (would put a + formal charge on F).

10) **[5 marks]** Complete the following table for the SO_2F_2 molecule (S the centre atom):

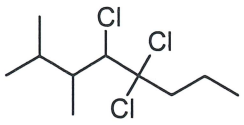
- Include all non-zero formal charges.
- Circle the "best" resonance form.
- Draw only non-equivalent resonance forms.

I'll mark only what you write in the table; you can use the rest of the page for rough work (if you wish).

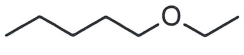
Resonance Form 1	Resonance Form 2	Resonance Form 3
		

all zero formal charges

11) **[10 marks]** Give IUPAC (or other acceptable) names for the following compounds:

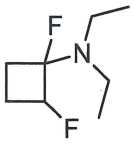
a) 

2,3-dimethyl-4,5,5-trichlorooctane

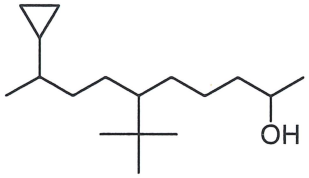
b) 

(as an ether) ethyl pentyl ether

(NOT as an ether) 1-ethoxypentane

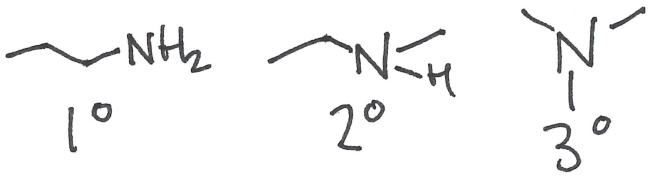
c) 

N,N-diethyl-1,2-difluoro cyclobutan-1-amine

d) 

6-t-butyl-9-cyclopropyldecan-2-ol

12) **[3 marks]** Use the formula C_3H_9N to draw one example each of a primary, secondary, and tertiary amine. You do not need to name the compounds you draw, and you may use either the shorthand notation (as discussed in class) or draw all atoms.

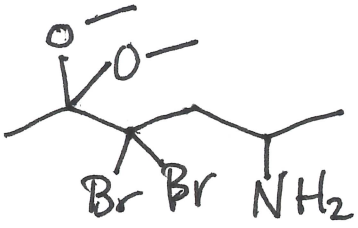


13) **[8 marks]** Give structures consistent with the following names:

a) 1,1-diethyl-4-methoxy-2,2-dimethylcyclohexane

b) 2-chloroethyl ethyl ether

c) 4,4-dibromo-5,5-dimethoxyhexan-2-amine



d) 2,2-difluoro-3-pentylcyclopropanol